BES R measurements and J/ψ decays

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R measurement results in 2 – 5 GeV region by BESII is reported in this talk. The study on σ particle in $J/\psi \to \omega\pi^+\pi^-$, based on 7.8×10^6 BESI J/ψ data, is also reported.

1 BES R Measurements

R is defined as,

$$R = \frac{\sigma(e^+e^- \to \ hadrons)}{\sigma(e^+e^- \to \ \mu^+\mu^-)} = 3\sum_q Q_q^2$$

A precision measurement of R will reduce the uncertainty on $\alpha(M_z)$, narrow the predicted mass window of Higgs boson m_H and reduce the uncertainty on the anomalous magnetic moment of muon a_μ. R has been measured in the energy region from hadron production threshold to Z^0 pole. Previous R measurements below 5 Gev were carried out almost 20 years ago and the largest uncertainty on R comes from the measurement below 5 GeV energy region. Therefore, it is important to measure R value in the 2 – 5 GeV energy region. BES collaboration has carried out two runs of R scan. 6 energy points were scanned in the 1998's run. Data samples at 2.6 GeV and 3.55 GeV were used to tune LUND parameters[1]. In the second run of 1999, 85 energy points were scanned, from which 24 points with separated-beam data and 7 points with sigle-beam data. In the experiment, R is determined by the following realtion:

$$R = \frac{\sigma^0 had}{\sigma^0_{\mu\mu}} = \frac{N^{obs}_{had} - N_{bg} - \sum_l N_{ll} - N_{\gamma\gamma}}{\sigma^0_{\mu\mu} \cdot \varepsilon_{had} \cdot \varepsilon_{trg} \cdot (1+\delta) \cdot \mathcal{L}},$$

where N^{obs}_{had} represents the observed hadronic events, N_{bg} represents the beam-associated backgrounds, N_{ll} represents the lepton pair backgrounds,

$N_{\gamma\gamma}$ represents two photon process events, ε_{had} stands for the detection efficiency, ε_{trg} is the trigger efficiency, $(1+\delta)$ is the radiative correction, $\mathcal{L}$ is the integrated luminosity and $\sigma^0_{\mu\mu}$ is the lowest cross section of $e^+e^- \to \mu^+\mu^-$ which is given by $\sigma^0_{\mu\mu}(s) = 4\pi\alpha^3/3s$. One of the most important work in R measurements is hadronic event selection. It is done in three steps. First remove apparent Bhabha events. Then in track level, select track to remove cosmic rays, beam-gas. Finally, in event level, remove beam-gas, two-photon, ee, $\mu\mu$, $\cdots$. The main backgrounds come from cosmic rays, lepton pair production, two-photon processes and beam associated background. The most serious background is beam associated background. It is studied in two independent methods. The first method is to use separated-beam data to calculate the event number of beam associated background, the second method is to use z component of event vertex to calculate the event number. The results given by two different method are consistent. Detection efficiency is given by Monte Carlo simulation, which is model dependent. However, results given by different models are consistent in 3 percent level. The integrated luminosity is determined by $L = \frac{N_{obs}}{\sigma\cdot\varepsilon\cdot\varepsilon_{trg}}$, with N_{obs} the number of events (Bhabha, dimuon and $\gamma\gamma$), σ the production cross section, ε_{trg} the trigger efficiency and ε the detection efficiency. Initial state radiative correction is studied in four different schemes and they are consistent within 1% in continuum region. Finally, Crystall Ball scheme is selected to calculate the radiative correction. Uncertainties of R values are reduced down to $6 \sim 10\%$. The average uncertainties of R is about 6.6%. As an example, the error source of R value at 3.0 GeV energy point is shown in Table 1. R values in $1-5$ GeV energy region is shown in Fig.1[2].

Source	N_{had}	L	$1+\delta$	ε_{had}	Sys.	Stat.	Total
Error contribution (%)	3.3	2.3	1.3	3.0	5.2	2.5	5.8

Table 1: Error Source (3.0 GeV as example)

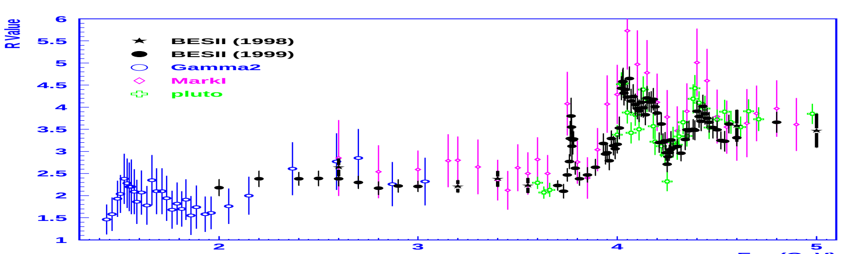

Figure 1: R values in $1-5$ GeV energy region

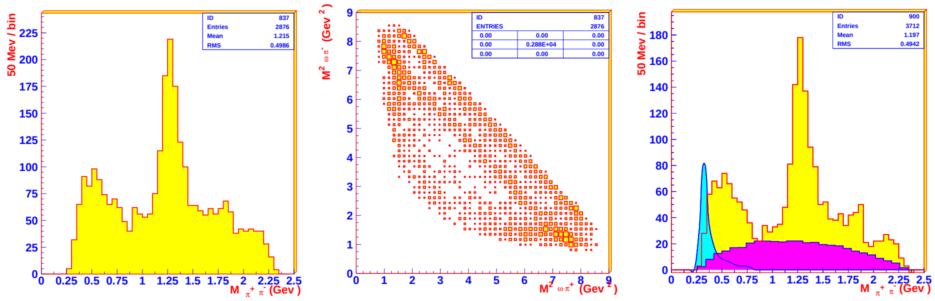

Figure 2: LEFT:The invariant mass spectrum of $\pi^+\pi^-$; MIDDLE:Daliz plot; RIGHT: mass spectrum after side-band subtraction.

2 Search for σ in J/ψ Hadronic Decay

The early analysis of $\pi\pi$ and πK scattering data shows no pole at the lower mass region. Up to now, the existence of σ and κ as resonant particles has not been widely accepted. However, recent re-analysis of the $\pi\pi$ and πK scattering data shows an evidence for existence of the σ and κ particle with comparatively light mass[3]. If σ is a s-channel resonance, it should appear in production process. Therefore, it is important to search for σ and κ in production process.

One found that there is a low mass enchancement in the $\pi^+\pi^-$ invariant mass spectrum in $J/\psi \to \omega\pi\pi$ (Fig.2). For the sake of complicity, we call this low mass enhancement the σ-particle. In Daliz plot, a clear band which corresponds to the σ-particle can be seen(Fig.2). There are some backgrounds in the above data sample (such as $J/\psi \to \rho 3\pi$, $\cdots$). Some of the backgrounds are shown in the ω side-band, which can be removed through side-band subtraction. σ-particle can still be observed in the $\pi^+\pi^-$ invariant mass spectrum after side-band subtraction (Fig.2). Threshold effects and phase space effects can also be seen in this figure. Apparently, the first peak does not originate from threshold effect and phase space effect. We also performed detailed Monte Carlo study and found that the background events from other J/ψ decay channels are very less. Therefore, the first peak is likely a s-channel resonance. Then, a Partial Wave Analysis(PWA) on the $\pi^+\pi^-$ invariant mass spectrum is applied to study the structure of the first peak. Our results strongly favor that the spin-parity is 0^{++} and the statistical significance of σ is about 18 σ. Its mass and width are determined through mass and width scan and the results are listed in Table 2.

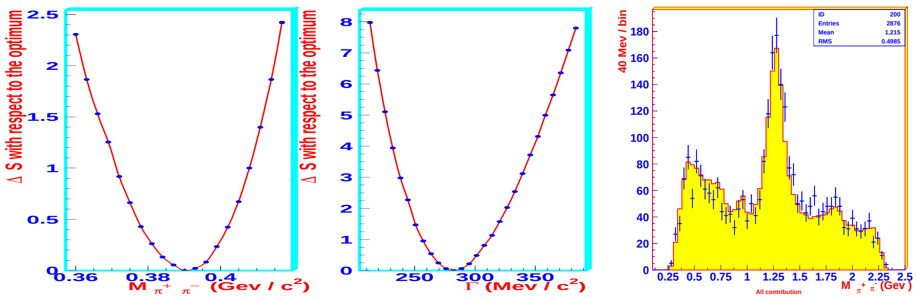

Figure 3: LEFT: Mass scan on σ; MIDDLE:width scan on σ; RIGHT: final global fit(error bar is real data and histogram is fit).

Our scan curve is shown in Fig.3 with the cross representing real data and the histogram being fit curve. The final fit on the global mass spectrum is also shown in Fig.3. $f_0(980)$ also appears in this channel. Our results on $f_0(980)$ is listed in Table 2. The branching ratios listed there are only for $J/\psi \to \omega X \to \omega\pi^+\pi^-$.

Resonance	M (MeV)	Γ (MeV)	BR ($\times 10^{-4}$)
σ-particle	390^{+60}_{-36}	282^{+77}_{-50}	$17.1 \pm 3.4 \pm 4.3$
$f_0(980)$	976^{+22}_{-20}	78^{+63}_{-43}	$2.80 \pm 0.56 \pm 0.4$
$f_2(1270)$	1280^{+13}_{-12}	164^{+29}_{-27}	$43.5 \pm 8.7 \pm 5$

Table 2: Final results of some main resonances.

σ, as a s-channel resonance, is not found in the $J/\psi \to \gamma\pi^+\pi^-$ It means that it does not look like a scalar glueball. According to quark model, the ordinary $q\bar{q}$ scalar meson nonet with lowest mass is 1^3P_0 states. Its orbital angular momentum is excited to P wave. The mass of them can not be as low as 390 MeV. σ can not be filled into the quark model for ordinary $q\bar{q}$ mesons.

References

[1] J. Z. Bai *et al.*, (BES Collab.), Phys.Rev.Lett **84** 2000:594.

[2] J. Z. Bai *et al.*, (BES Collab.), "MEASUREMENTS OF THE CROSS-SECTION FOR $e^+e^- \to$ HADRONS AT CENTER-OF-MASS ENERGIES FROM 2-GEV TO 5-GEV", hep-ex/0102003

[3] S.Ishida, M.Y.Ishida, H.Takahashi, T.Ishida, K.Takamatsu and T.Tsuru, *Prog.Theor.Phys.* **95**, (1996) 745